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(54) **SELF-DRILLING ROCK BOLT ASSEMBLY AND METHOD OF INSTALLATION**

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E02D 7/22	(2006.01)
E21D 20/00	(2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

USPC 405/259.1

See application file for complete search history.

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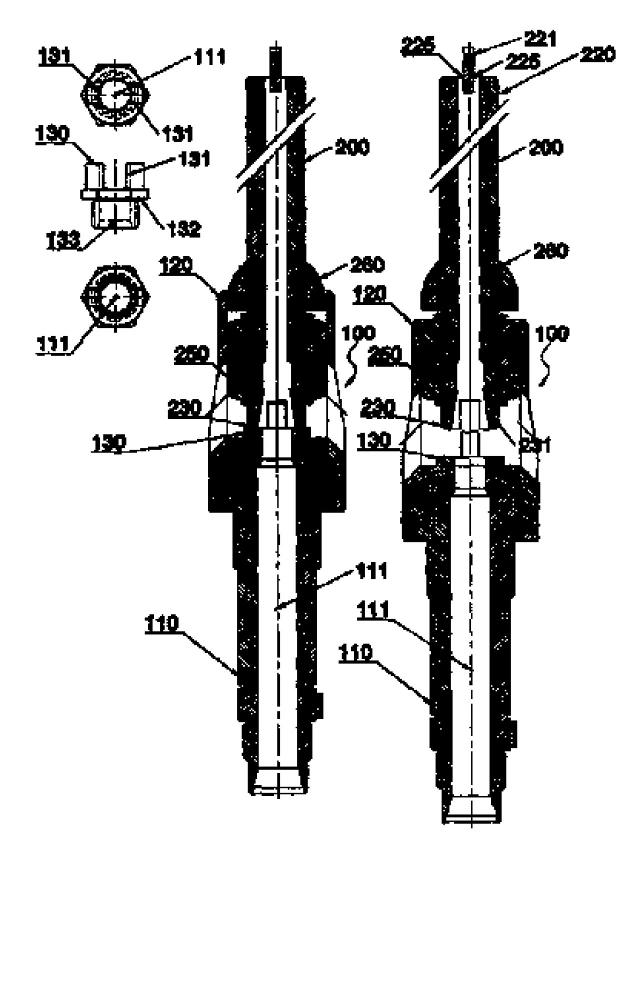
(57) **ABSTRACT**

A self-drilling rock bolt assembly (**1**) including a drill head mechanism (**100**) and a fluid delivery system (**300**) operatively associated with each other and adapted in use to secure a self-drilling rock bolt (**200**) into a strata (**2**). The rock bolt (**200**) having a shaft (**210**) having a cutting end (**220**) and a driving end (**230**). The drill head mechanism (**100**) having a bolt coupling portion (**130**) to releasably engage with the driving end (**230**) of the rock bolt (**200**). Wherein rotation of the bolt coupling portion (**130**) rotates the rock bolt. A central hollow portion (**111**) provides access to a fluid connection port (**232**) of the rock bolt and a nut coupling portion (**120**) releasably engages with a nut element (**250**) located on the shaft of the rock bolt. Wherein rotation of the nut coupling portion rotates the nut element. The fluid delivery system (**300**) has an injection nozzle (**320**) in communication with one or more sources of fluid for delivering measured quantities of one or more fluids to a predetermined location about said assembly. Each source of fluid including a reservoir (**310**, **311**, **312**) in fluid communication with a pump (**313**, **314**, **315**). The pump being in fluid communication with the injection nozzle so that said fluid from said reservoir is adapted to be pumped to said predetermined location. Whereby in use said drill head mechanism drives the rock bolt into the strata by rotating in a drilling direction the rock bolt and nut element at the same rate such that the nut element remains in the same position relative to the shaft of the rock bolt.

20 Claims, 9 Drawing Sheets



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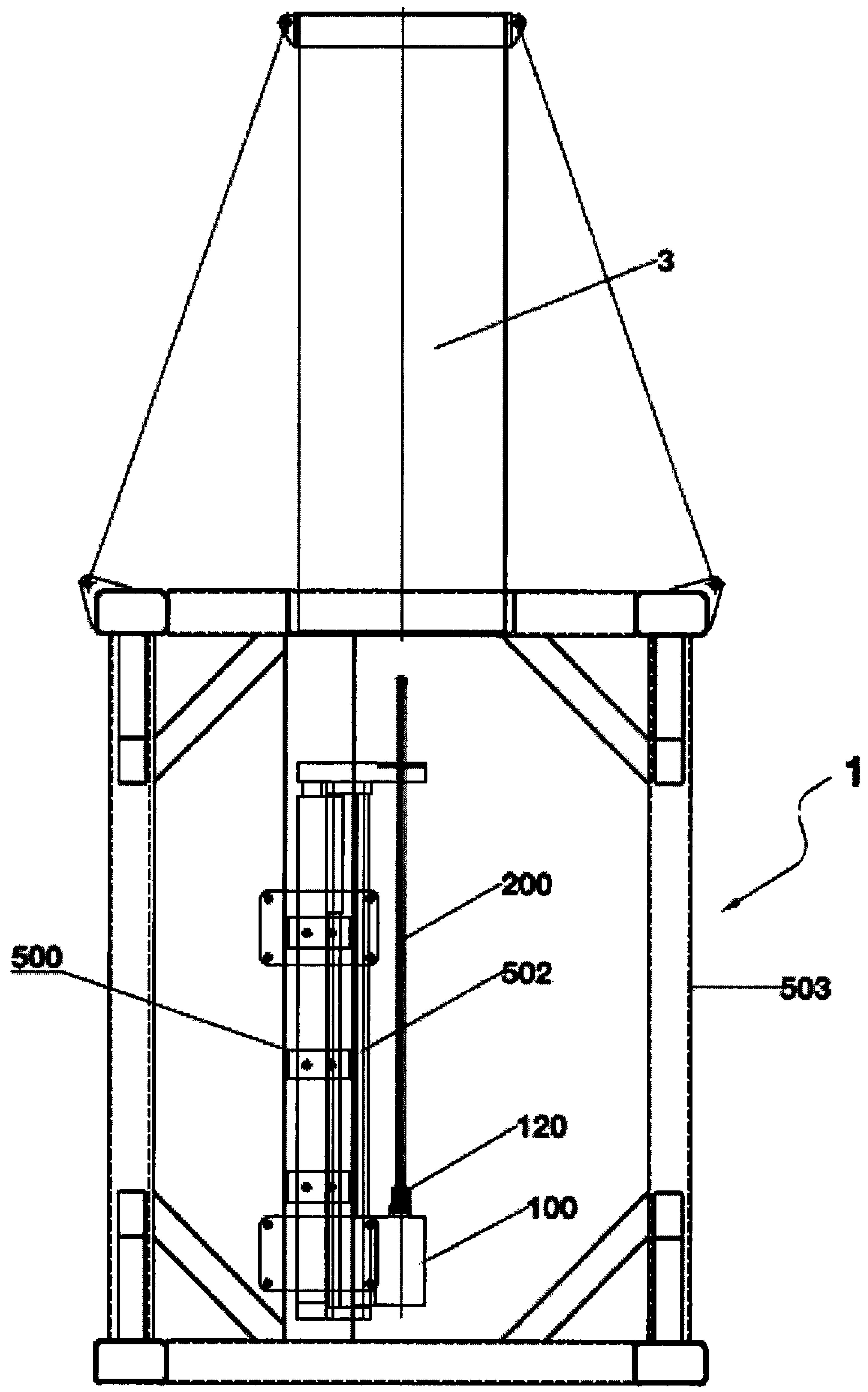

FIG. 1

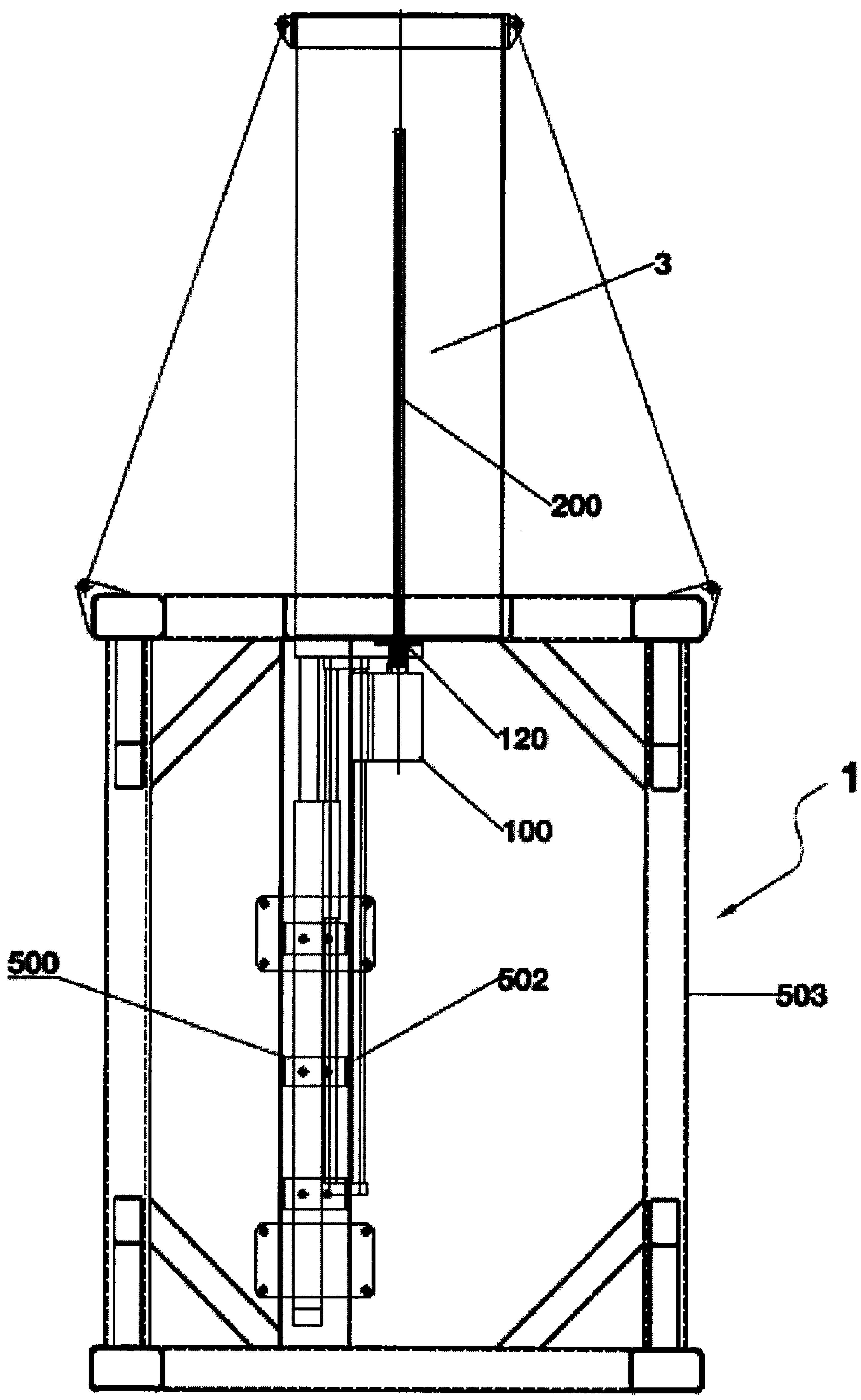

FIG. 2

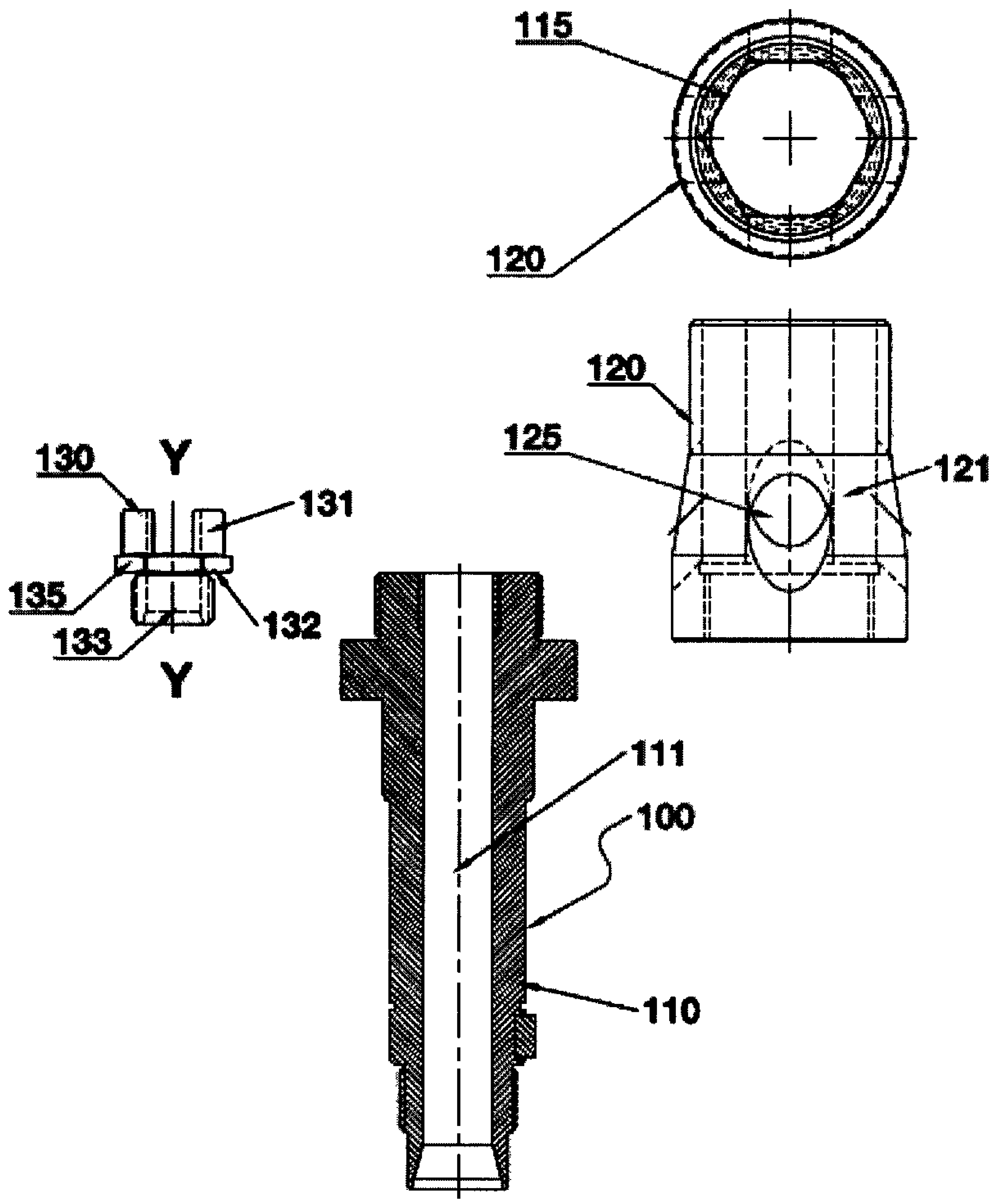

FIG. 3

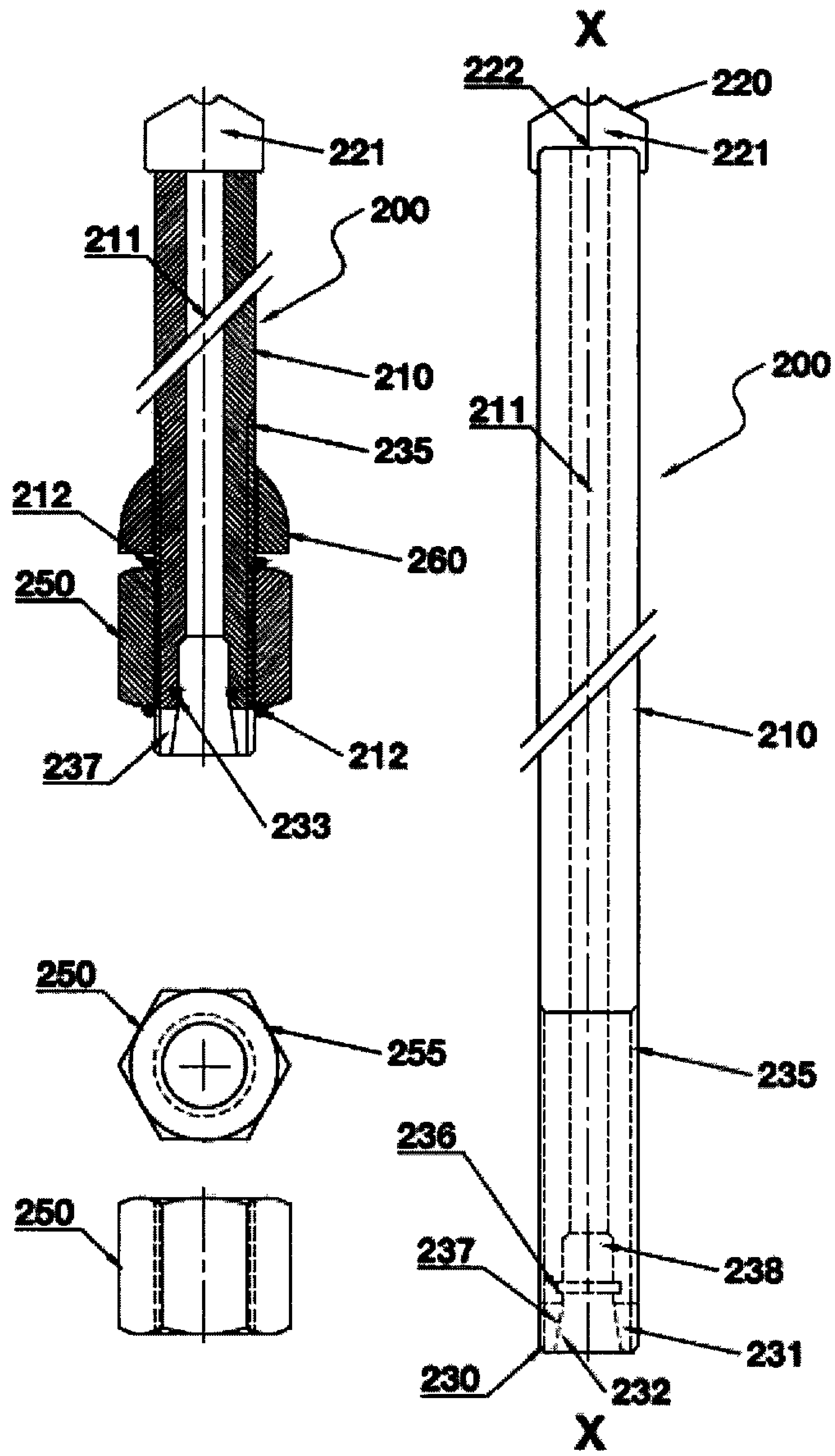
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FIG. 4

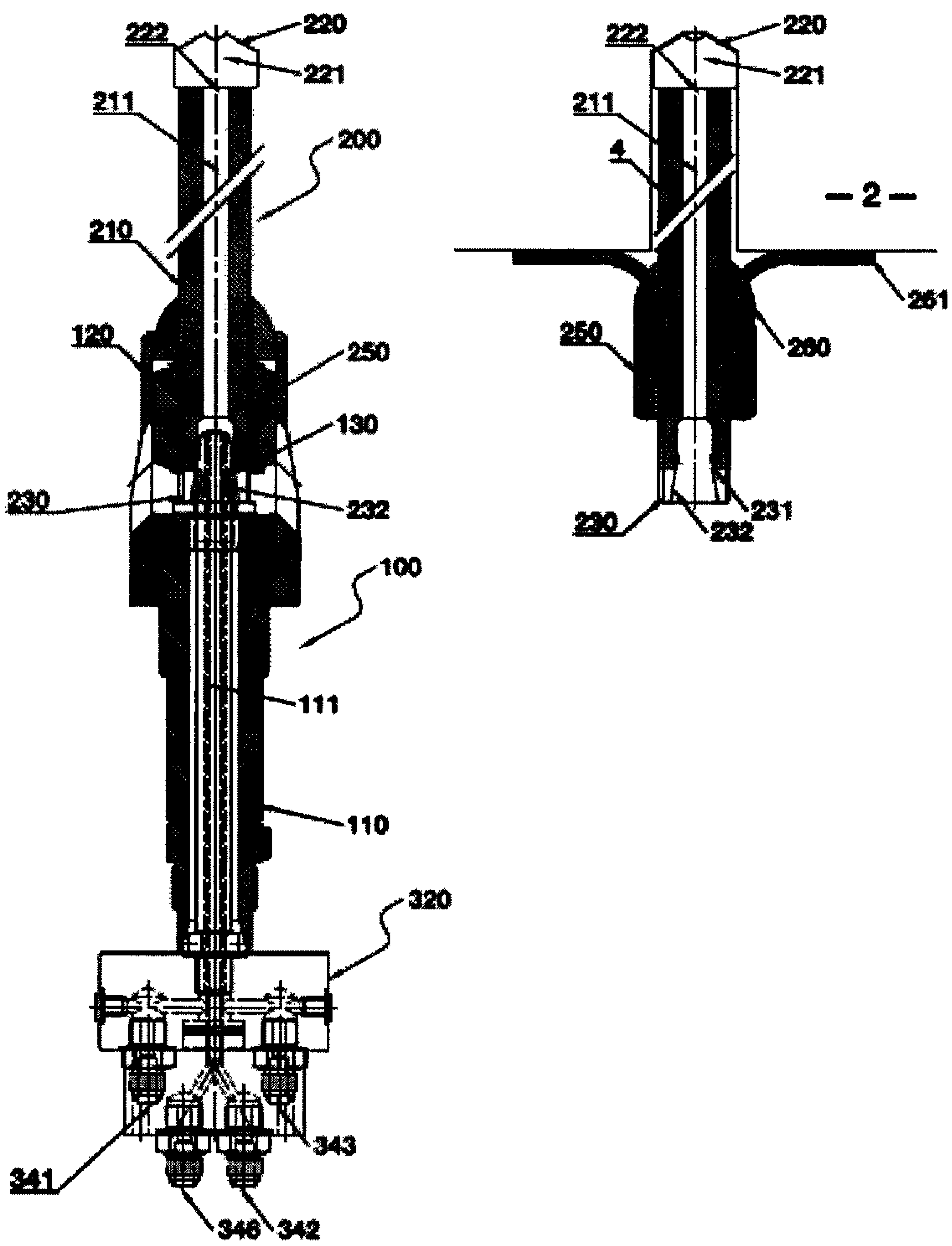
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FIG. 5

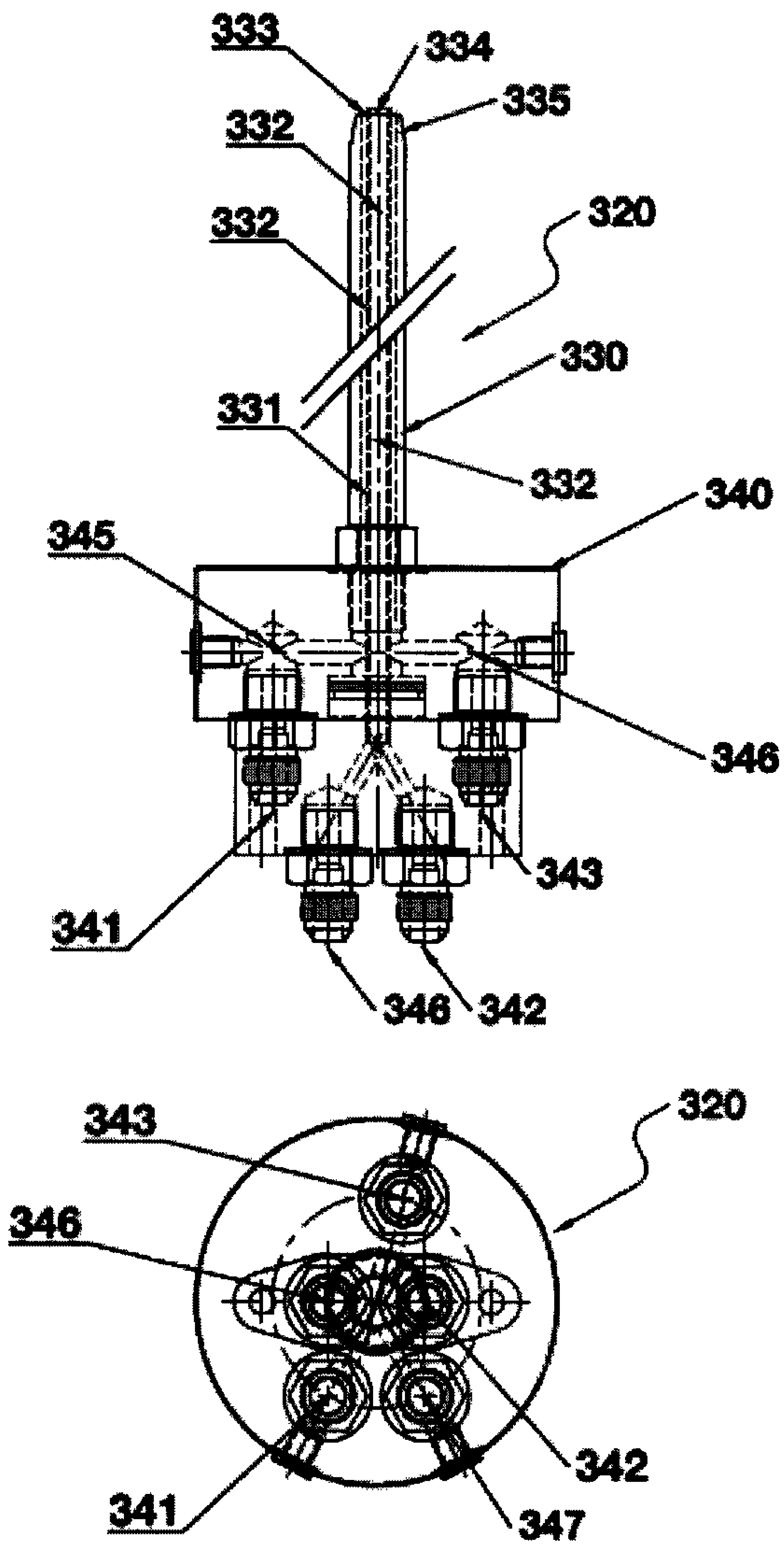
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FIG. 6

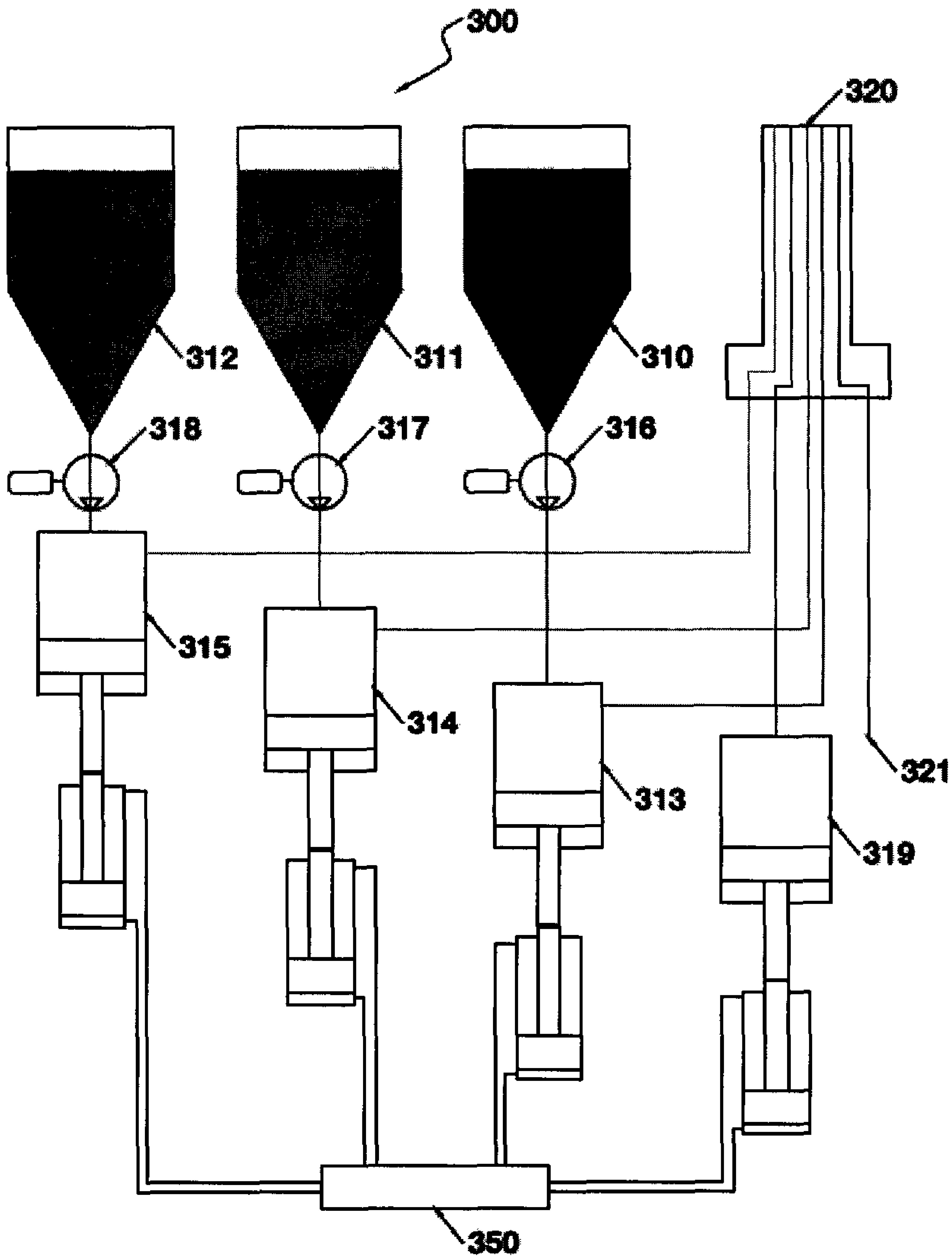

FIG. 7

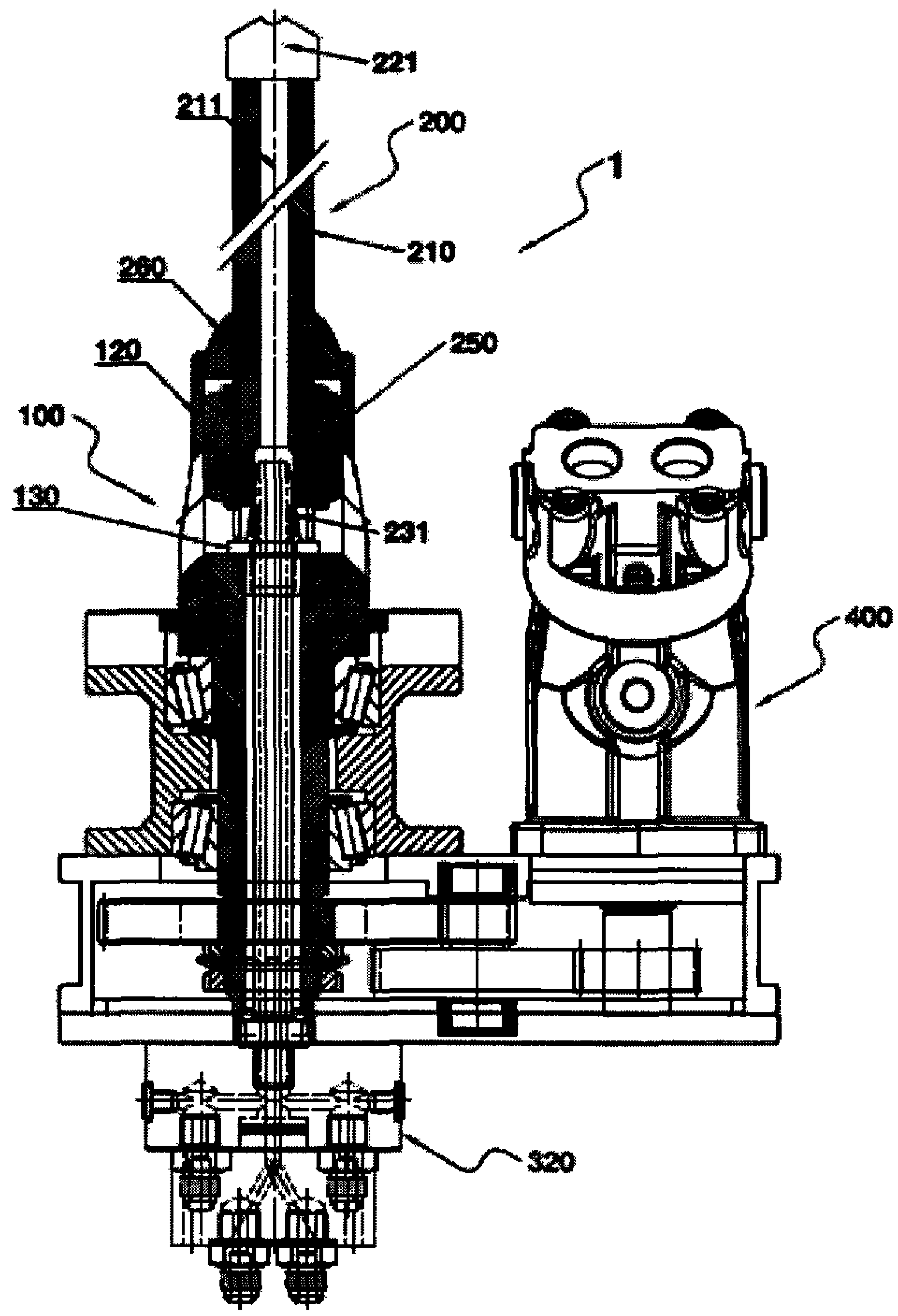

FIG. 8

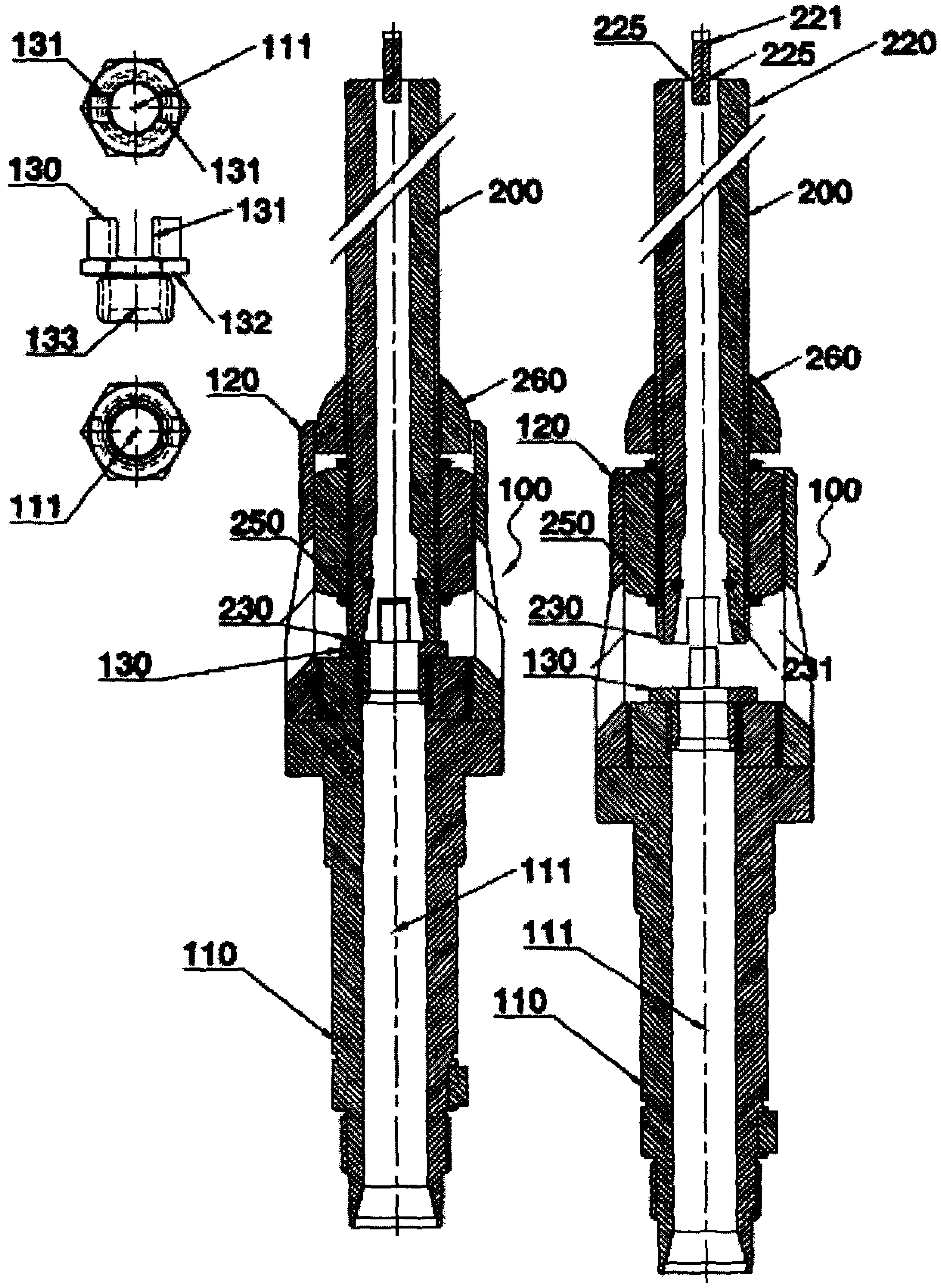
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FIG. 9

SELF-DRILLING ROCK BOLT ASSEMBLY AND METHOD OF INSTALLATION

FIELD

The present invention relates to a self-drilling rock bolt assembly and method of installation. In particular, a semi or fully automated self-drilling rock bolt assembly to operate on a continuous miner, tunnel boring machine, mobile bolting machine, building/construction bolting into concrete tools or the like.

BACKGROUND

Rock bolts are common throughout the world and are typically drilled into strata and retained therein to provide support to the integrity of the strata which assists with supporting structures. For example, rock bolts can be used in the construction and maintenance of mines, tunnels, passageways, canals, enclosures, shafts, halls, access ways, subways or the like.

In underground tunneling, for example, rock bolts are often installed at progressive intervals along the tunnel. During the construction of the tunnel it is desirable to provide a rock bolt that is easy to secure into the strata with the least human intervention due to the highly hazardous environment.

The most common method of securing a rock bolt to strata is to drill a hole in the strata using a drill rig with a drill rod. Once the hole has been bored and the drill rod is retracted from the hole, the drill rod is removed from the drill chuck. A bolt is then inserted into a drive dolly which is an adapter between the bolt and drive chuck. A resin capsule is then inserted into the bored hole. The bolt is then inserted into the bore hole causing the resin capsule to rupture. The bolt is then rotated to promote mixing and dispersion of the resin. Once the resin has set, a nut on the end of the bolt is rotated and the nut comes into contact with the collar of the hole. Torque is applied to the nut on contact with the collar of the borehole and the nut places tension over the length of the bolt that has not been already anchored to the strata. As a result, the strata is then placed in compression, containing the strata.

The above described bolting method has many steps and involves a high level of manual handling. Repetitive manual handling tasks of this type ultimately lead to accidents and injuries. The speed of installation of a bolt is governed by the proficiency of the operator, and this can vary considerably. Production demands require an efficient installation time for strata support, however, this method takes time due to the many steps involved.

Self-drilling rock bolts were developed to overcome the above disadvantages. They are known for providing a single drilling and securing function. This negates the need to drill a hole, withdraw the drill rod and subsequently insert a bolt into the hole using various methods of anchoring.

Hollow, steel, self drilling rock bolt versions have been developed to minimize the number of cycles involved when rock bolting strata. One self drilling rock bolt utilizes the centre hole of the bolt as the delivery port for water during the drilling process as well as an avenue to pump cement grouts and resins of various sorts to anchor and encapsulate the bolt. The self drilling rock bolt is then simply filled both internally and externally about the bolt annulus, and therefore provide a dowel support to the strata. No tension is applied to the length of the bolt in the strata.

Mechanically anchored self drilling rock bolts are also available. They can be used in combination with cement grouts or resins that are inserted post anchoring with the mechanical anchor. However, the mechanical anchor technique can also fail when the surrounding borehole strata is weak and is unable to provide sufficient resistance to allow tensioning. The bolt is heavier than alternate options and the system is also slow due to the post grouting step for full encapsulation.

Another self-drilling rock bolt system utilizes a hollow bar with a chemical resin capsule already placed in the centre of the bar. Water is used as the drill and flush medium and travels through the middle of the bolt. Once the hole is drilled using the bolt, water is delivered into the cavity of the bolt containing the resin capsule. The water forces the resin capsule to disperse and mix before flowing around the annulus of the bolt. When the chemical resin has set, the bolt has reinforced the strata in the form of a dowel. The disadvantage of this system is that the bolt is very expensive to manufacture due to the internal arrangements within the bolt. Also, each bolt then has a shelf life based on the resin cartridge expiration.

In addition to the above disadvantages, existing self-drilling rock bolts, though used throughout the world, are expensive, time consuming to install, heavy, cumbersome and complicated to install correctly. Also full automation has not yet been achieved for installing traditional self-drilling rock bolts. Mechanical anchors, static mixers, individual chemicals, springs and the like also make known self-drilling rock bolt systems non automatable. Mechanical anchors in soft strata conditions can also fail and therefore won't allow the bolt to be pre-tensioned.

It is beneficial to apply pre-tension to an installed rock bolt to provide greater resistance to any strata movement. This can be accomplished by applying tension to the rock bolt once it has been secured to the strata by the hardening substance for a predetermined distance along the bolt effectively straining the bolt longitudinally, and then securing the rock bolt in tension using the nut and thread against the drill hole collar.

Accordingly, there is a need to provide a rock bolt drill head mechanism, a self-drilling rock bolt, a fluid delivery system and a method for securing the self-drilling rock bolt to strata that separately (or together) provides that the strata is supported quickly, reliably and efficiently, increases worker safety, provides significant automation, can be pre-tensioned, provides a multi-use injection system for use with multiple substances, reduces costs, provides productivity improvements and reduces the amount of human intervention and hence improves safety at an operation site.

OBJECT OF INVENTION

It is an object of the present invention to substantially overcome or at least ameliorate one or more of the disadvantages of the prior art, or to at least provide a useful alternative.

SUMMARY OF INVENTION

In one broad form, the present invention discloses a self-drilling rock bolt assembly including a drill head mechanism and a fluid delivery system operatively associated with each other and adapted in use to secure with pre-tension, chemically, via injection, a self-drilling rock bolt into a strata; the rock bolt including a shaft having a cutting end and a driving end; the assembly including:

a. the drill head mechanism having:

a bolt coupling portion to releasably engage with the driving end of the rock bolt, wherein rotation of the bolt coupling portion rotates the rock bolt;

a central hollow portion providing access to a fluid connection port of the rock bolt; and,

a nut coupling portion to releasably engage with a nut element located on the shaft of the rock bolt, wherein rotation of the nut coupling portion rotates the nut element;

b. the fluid delivery system having:

an injection nozzle in communication with one or more sources of fluid for delivering measured quantities of one or more fluids to a predetermined location about said assembly,

each source of fluid including a reservoir in fluid communication with a priming pump, the priming pump being in fluid communication with the displacement pump, the displacement pump being in fluid communication with the injection nozzle, so that said fluid from said reservoir is adapted to be pumped to said predetermined location;

a cleaning flush phase for each separate internal passage within the injection nozzle, that has each cleaning fluid sourced from a different reservoir pressure source;

whereby in use said drill head mechanism drives the rock bolt into the strata by rotating in a drilling direction the rock bolt and nut element at the same rate such that the nut element remains in the same position relative to the shaft of the rock bolt.

Preferably, the nut coupling portion drives an outside surface of the nut element.

Preferably, the bolt coupling portion includes one or more male connectors that engage with one or more corresponding female connectors of the rock bolt, the male connectors driving an inside surface of the rock bolt.

Preferably, the bolt coupling portion includes a main body with a central hollow corresponding to the central hollow of the drill head mechanism, wherein the one or more male connectors include a protrusion from a top surface of the main body extending in a direction parallel to a longitudinal axis of the central hollow and adapted to operatively couple with the female connector in the driving end of the rock bolt.

Preferably, in a first position the nut coupling portion is engaged with the nut element and the bolt coupling portion is engaged with the driving end of the rock bolt, and in a second position the nut coupling portion is engaged with the nut element and the bolt coupling portion is disengaged with the driving end of the rock bolt.

Preferably, the drill head mechanism advances the nut element along the rock bolt by rotating in the drilling direction while in the second position thereby tensioning the rock bolt.

In a further form there is disclosed herein a self-drilling rock bolt, the rock bolt including:

the shaft having a hollow portion defining a central conduit;

the fluid connection port containing a fluid seal;

the cutting end at one end of the shaft where a cutting tip is fixed; and,

the driving end at the other end of the shaft adapted to operatively female couple to the drill head mechanism, wherein rotation of the drill head mechanism rotates the shaft;

the shaft including an external thread at or towards the driving end that engages with the nut element such that rotation of the nut element relative to the shaft causes the nut element to move in an axial direction along the shaft.

Preferably, the central conduit provides fluid communication between a fluid connection port at the driving end and a fluid exit at the cutting end. A seal in the fluid connection port at the driving end of the central conduit ensures that there is no fluid leakage at the fluid connection and that all fluids exit the central conduit at the cutting end.

Preferably, the coupling end includes one or more slots arranged radially about the fluid connection port, each slot adapted to receive therein a male connector of the bolt coupling portion of the drill head mechanism.

Preferably, the cutting tip is fixed to the rock bolt so that it creates a fluid exit for fluids to exit the central conduit.

Preferably, the assembly further includes a mesh screen surrounding the rock bolt to permit fluid to exit a void surrounding the rock bolt by flowing through the mesh screen but resists higher viscosity hardening substances flowing therethrough to exit the void.

Preferably, the fluids include one or more of: a slow set hardening substance; a fast set hardening substances; a catalyst to initiate the hardening of the slow and/or fast set hardening substance; water; steam; gas; air; cleaning fluid; and/or flushing fluid.

Preferably, the assembly further includes a control system to control the ratios and volumes of each fluid supplied to the rock bolt and movement of the drill head mechanism with respect to the strata.

Preferably, the injection nozzle includes:

a plurality of separate internal passages through which various fluids may flow;

a needle portion of elongate shape, with one end adapted to couple with the rock bolt and including openings for fluids to exit the internal passages; and,

a base portion including fluid inlets in fluid communication with the internal passages.

Preferably, the base portion of the injection nozzle includes a plurality of separate inlets, wherein more than one of the inlets may be in fluid communication with the same internal fluid passage.

Preferably, the injection nozzle in use extends through the central hollow of the drill head mechanism into the fluid connection port while the drill head mechanism is coupled with the rock bolt, and whereby in use the injection nozzle does not rotate as the drill head mechanism and/or rock bolt rotates.

In a further form there is disclosed herein a method of installation of the self-drilling rock bolt assembly, the method including the steps of:

rotating the rock bolt and the nut element together in the drilling direction using the drill head mechanism such that the rock bolt advances into the strata;

delivering the hardening substances by the fluid delivery system;

spinning the rock bolt; and,

tensioning the rock bolt by rotating the nut element in the drilling direction relative to the rock bolt so that the rock bolt is anchored in the strata.

Preferably, the method further includes the steps of:

a. a slow setting hardening substance is first sent through the rock bolt, then

b. a fast setting hardening substance is sent through the rock bolt; then either or both;

c. a slow setting hardening substance is sent into the central conduit of the rock bolt; and/or

d. a cleaning fluid is sent into the central conduit of the rock bolt; so that the rock bolt is tensioned after the fast setting hardening substance has hardened and before the slow setting hardening substance has hardened.

Preferably, the drill head mechanism rotates the rock bolt and nut element at the same rate in a drilling direction, causing the rock bolt to be drilled into the strata, then decouples from the rock bolt; but is still coupled to the nut via the nut coupling portion, and further rotates in the drilling direction or opposite the drilling direction to cause the nut element to advance along the rock bolt, thereby causing the rock bolt to be placed in tension.

Preferably, the fluid delivery system supplies a plurality of different fluids throughout the assembly as determined by the control system.

DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the following detailed description of preferred but non limiting embodiments thereof, described in connection with the accompanying drawings, wherein:

FIG. **1** is the test apparatus to install a self-drilling rock bolt assembly **200** in test substance **3** shown in the start position.

FIG. **2** is the test apparatus to install a self-drilling rock bolt assembly **200** in test substance **3** shown in the installed position.

FIG. **3** includes an exploded side view of a drill head mechanism as well as a plan view of a nut and bolt coupling portions;

FIG. **4** includes a cross sectional view of a self-drilling rock bolt without the nut element as well as a further cross section view of a self-drilling rock bolt including a nut element and dome washer. In addition, there is shown a front elevation and a plan view of a nut element;

FIG. **5** is a cross sectional view of an assembly including injection nozzle, drill head mechanism and self-drilling rock bolt and also a cross sectional view of a self-drilling rock bolt anchored in a rock substrate together with a plate washer;

FIG. **6** includes a cross sectional view and a plan view of an injection nozzle;

FIG. **7** is a schematic layout of a fluid delivery system in connection with a schematic representation of an injection nozzle;

FIG. **8** is a cross sectional view of a drive head mechanism, injection nozzle and self-drilling rock bolt operationally coupled to a drill motor; and,

FIG. **9** includes plan view, side elevation and bottom view of the bolt coupling portion of the drill head mechanism as well as two cross section views of the drill head mechanism in a first position where the bolt coupling portion is engaged with the female connector of the self-drilling rock bolt, and a second position where the bolt coupling portion is not engaged with the female connector, the nut coupling portion being engaged with the nut element in both positions.

DETAILED DESCRIPTION

Throughout the drawings, like numerals will be used to identify similar features, except where expressly otherwise indicated.

In FIGS. **1** and **2** is shown a test apparatus for installing self-drilling rock bolts **200** in a test substance **3**. The test apparatus frame **503** carries the test substance **3** and the loads incurred while installing a self-drilling rock bolt **200** with drilling assembly **500**. The articulation system of the test apparatus allows multiple self-drilling rock bolts **200** to be installed in test substance **3**. In a preferred, but non limiting embodiment, as best seen in FIGS. **1**, **2** and **8** the present invention relates to a self-drilling rock bolt assembly **1** that includes a drill head mechanism **100** and a fluid delivery system **300** operatively associated with each other and adapted in use to secure a self-drilling rock bolt **200** into a strata **2**. In particular, the drill head mechanism **100** installs self-drilling rock bolts **200** either under tension or not under tension. In a preferred form, they would be installed under tension.

Rock bolts **200** are typically used for supporting roof, wall and/or floor structures in the construction and maintenance of mines, tunnels, passageways, canals, enclosures, shafts, halls, access ways, subways or the like. A plurality of self-drilling rock bolts **200**, as illustrated in FIG. **4**, are used in cooperation with the assembly **1**. The speed at which the rock bolts **200** are installed by using the assembly **1** will be determined mostly by the level of automation used and the speed at which the drilled strata can be removed from the drilling site. The rock bolt **200** includes a longitudinally extending main shaft **210** that has a central conduit **211** defining a longitudinal axis X, a cutting end **220** where a cutting tip **221** is fixed and a driving end **230**. The main shaft **210** also has an external thread **235** located towards the driving end **230** with which a nut element **250** engages, such that the nut element **250** moves along the outside of the main shaft **210** when rotated relative to the main shaft **210**. The rock bolt **200** will typically be made from steel with either a ribbed or plain outer surface, however can be made from any other suitable material. Other materials that could be used include, but are not limited to, carbon fibre, fiberglass, Kevlar™ composite, other composite materials, plastic or metals and alloys other than steel, galvanized, anti-rust materials or the like.

The cutting tip **221** of the rock bolt **200** includes a piece (or a number of pieces) of tungsten carbide, hardened steel or some other suitable material depending upon the drilling material. In the preferred embodiment, the piece fits into a slot (not shown) in the cutting end **220** of the rock bolt **200**. The piece is braised, welded, threaded, screwed, adhesively bonded, snap lockingly engaged or the like in place. In the preferred form, the central conduit **211** extends right to the ends **220**, **230** of the rock bolt **200**, however as the cutting tip **221** extends across the rock bolt **200** it divides the exit into two smaller openings **225**, one on either side of the cutting tip **221** as best seen in FIG. **9**. Many alternative cutting tip designs are possible and these may result in a single fluid exit or many fluid exits. For example, the cutting tip **221** is fixed to the rock bolt **200** to create or provide one or more fluid exits **225**. The exits **225** can be located in any location such as the centre, sides or the like.

Referring to FIG. **3**, the drill head mechanism **100** is shown split into three main component parts. The main component parts comprise a main body **110**, a nut coupling portion **120** and a bolt coupling portion **130**. The main parts could be integrally formed into a single unit or be separate parts operatively associated with each other in use. FIGS. **5**, **8** and **9** show the drill head mechanism **100** with the three main component parts in the assembled state for installing self-drilling rock bolts **200**.

As best seen in FIGS. **3** to **5**, the drill head mechanism **100** is able to couple with both the nut element **250** and the driving end **230** of the rock bolt main shaft **210**. The nut coupling portion **120** fits over the nut element **250** and is adapted to drive the outside surface **255** of the nut element

250 when the nut coupling portion **120** is rotated. The nut coupling portion **120** has an interior surface **115** which corresponds to the external profile **255** of the nut element **250**. In the present embodiment, the external profile **255** of the nut element **250** is a hexagonal cross section as best depicted in FIG. **4** which corresponds to a hexagonal profiled interior surface **115** (see FIG. **3**). However it will be appreciated that any suitable corresponding cross section that is capable of being driven may be used. For example, a triangle, octagon, square, rectangle or the like.

The nut coupling portion **120** includes one or more orifices **125** (as best seen in FIG. **3**) which pass through the side **121** of the nut coupling portion **120** and provide fluid communication from the bolt coupling portion **130** of the drill head mechanism **100** to allow excess material from the drilling, anchoring and tensioning of the self-drilling rock bolt **200** to exit with gravity assistance from the bolt coupling portion **130**. The material could be fluids, drill cuttings, debris, excess material, gases, dirt or the like.

The bolt coupling portion **130** is located in a central axial position of the drill head mechanism **100** and includes male connectors **131** (as best seen in FIG. **3**) that engage with corresponding female connectors **231** located at the self-drilling rock bolt **200** driving end **230**. In another embodiment, the male and female connectors **131**, **231** could be reversed. That is, the driving end **230** of the bolt **200** could have one or more male and/or female connectors **131**, **231**. The number of male and female connectors **131**, **231** can vary depending upon operation and need.

In the current embodiment, the bolt coupling portion **130** includes male connectors in the form of two tabs **131**, however any suitable number of tabs **131** may be used. As with the main body **110** of the drill head mechanism **100**, the bolt coupling portion **130** has a corresponding central hollow **133** to allow access to the fluid injection port **232** of the self-drilling rock bolt **200** when operatively engaged with the drill head mechanism **100**. The tabs **131** are arranged around the central hollow **133** and protrude out from the top surface **135** of the main body **132** of the bolt coupling portion **130** in a direction parallel to the longitudinal axis Y of the central hollow **133**. This allows the tabs **131** to fit into female connectors in the form of a slot or slots **231**, arranged around the fluid injection port **232** at the driving end **230** of the rock bolt **200**.

As shown in at least FIGS. **5**, **8** and **9**, when the drill head mechanism **100** rotates, the bolt coupling portion **130** rotates and the male connectors **131** to drive the inside surface **237** of the female connectors **231**. In the preferred embodiment, the bolt coupling portion **130** sits inside the nut coupling portion **120** such that it can couple to the rock bolt **200** from the end **230**, with the nut coupling portion **120** coupling to the outside **255** of the nut element **250** also located towards the driving end **230** of the rock bolt **200**.

The drill head mechanism **100** also includes a central hollow portion **111** that provides access to the fluid connection port **232** of the rock bolt **200**. In the current embodiment this is achieved with the injection nozzle **320** of the fluid supply system **300**. As best depicted in FIG. **6**, the injection nozzle **320** includes a needle portion **330** of elongate shape such that it can extend into the central hollow portion **111** through the length of the drill head mechanism **100**.

FIG. **5** shows the drill head mechanism **100** connected to the rock bolt **200** with the injection nozzle **320** inserted into the drill head mechanism **100** and coupled with the fluid connection port **232**. The fluid connection port **232** is in fluid communication with the central conduit **211**, allowing fluids to be delivered to the fluid exit **222** at the cutting end **220** of the rock bolt **200**. It should be appreciated that the configuration of the fluid exit **222** could be formed in a number of ways and include a variety of shapes, sizes and/or orientations to suit the fluid which could be a hardening substance, water, steam, gas, air, cleaning fluid, flushing fluid or the like. The exit **222** could also be utilised to permit material to exit the assembly **1** as mentioned above.

As shown in FIG. **6**, the end **335** of the injection nozzle **320** is tapered to aid coupling with the fluid connection port **232** and to match the internal shape **237** of the fluid connection port **232** of the self-drilling rock bolt **200**. The inside **237** of the fluid connection port **232** also contains a seal **233** that may be partially embedded in a slot **236** on the inside surface **237** or retained in some other manner. The seal **233** may be a standard O-ring, a crankshaft seal that allows easy insertion while aiding sealing as the internal pressure increases, or any other seal or sealing type device that may be suitable for such a purpose. It should be appreciated that seal **233** may be located within the slot **236** (as shown in FIG. **4**) or the internal surface **237** may be flush and the seal pushed up towards the top portion **238** of the port **232**.

In the preferred embodiment, the injection nozzle **320** does not rotate with rotation of the drill head mechanism **100** when inserted and coupled to the fluid connection port **232** of the self-drilling rock bolt **200**. That is, the needle **330** stays substantially still during operation as the rock bolt **200** rotates about it. This is advantageous as the needle **330** has a small diameter providing a low surface speed. Also, as the needle **330** is used many times during the life of the assembly **1**, if it rotated it (and its seals) would be worn out creating significant additional maintenance, down time and expenditure. The rock bolt **200** is only being used once and left in place in the strata **2**.

Referring to FIG. **6**, the injection nozzle **320** has at least two concentric passages including a central channel **332** and an outer channel **331** in the needle portion **330**. This allows at least two fluids to be supplied at the same time without the fluids mixing until they exit (**333**, **334**) the injection nozzle **320**. This is advantageous because hardening substances are typically made up of two components, with hardening only occurring after the components are mixed. The injection nozzle **320**, however, may have any number of internal passages **331**, **332** which may or may not be concentric.

For example, in a preferred embodiment, the slow setting hardening substance is made up of a slow set resin and a catalyst, while the fast setting hardening substance is made up of a fast set resin and a catalyst, wherein the same catalyst is used for the slow and fast setting hardening substances. This means a single catalyst may be delivered via the central channel **332** in the injection nozzle **320** and the slow and fast set resins may be supplied sequentially via the outer channel **331**. Alternatively, the resins may be delivered via the central channel **332** and the catalyst via the outer channel **331**. Any combination of fluid sources may supply any number of channels. There could be several different catalysts being delivered by separate channels and several different water or steam or air channels or the like being delivered by separate channels.

Referring to FIG. **6**, an example is shown where the fluid injection nozzle **320** also includes a base portion **340** with a catalyst inlet **342** and two resin inlets **341**, **343**. The fast set resin inlet **341** is connected by an internal channel **345** to the outer channel **331**, while the slow set resin inlet **343** is also connected to the outer channel **331** via an internal channel **346**. Two further inlets **348** and **347** deliver water to either the central channel **332** or the outer channel **331**.

Referring to FIG. **7**, the fluid delivery system **300** delivers the various fluids to the injection nozzle **320**. The embodiment shown includes hardening substances in the form of a fast and slow set resin which hardens in the presence of a catalyst. A slow set resin reservoir **311**, a catalyst reservoir **312** and a fast set resin reservoir **310** are shown in the drawings. A priming pump **317** draws from the slow set resin reservoir **311** which is in fluid communication with displacement pump **314**. Similarly a priming pump **318** draws from the catalyst resin reservoir **312** which is in fluid communication with displacement pump **315**. Similarly a priming pump **316** draws from the slow set resin reservoir **310** which is in fluid communication with displacement pump **313**. Water, gas, air, steam or the like is delivered via two different sources, **319**, **321** which are each delivered to the injection nozzle **320**. The two different sources are each directed to either the outer channel **331** or the central channel **332**. There could however be more than two sources.

Various valves and transducers are shown in the fluid delivery system **300** in FIG. **7**, which coordinate with the control system **350** to supply precise volumes of the various fluids at given times to the injection nozzle **320**. Exact volumes are required to ensure the correct portions of the rock bolt **200** are anchored with each resin. Also, ensuring exact ratios of resin to catalyst are essential to provide adequate hardening and predictable time taken for the substances to harden.

The fluid delivery system **300** may optionally include an additional supply of a different catalyst and/or one or more pressure supply sources **319**, **321** or an alternative fluid, gas, air, steam, vacuum or the like for use during the drilling process and/or after delivery of the resins and catalyst for cleaning, maintenance or the like. For example, an inert chemical could be used to flush the system. The fluid delivery system **300** may also remove or add any combination of reservoirs and associated components depending on the particular combination of fluids required in the drilling and anchoring process. Positive or negative pressure could also be provided to the system.

In the preferred embodiment, water is supplied to the central channel **332** and the outer channel from separate sources of water after the hardening and catalyst substances are delivered for cleaning purposes. However, any suitable fluid may be used in any or all of the channels for this purpose. Depending upon the reservoir size, the drilling and bolting process could continue indefinitely providing a continuous installation process.

In accordance with certain embodiments, there is also provided a method of drilling, anchoring and tensioning a self-drilling rock bolt **200** in to a strata **2**. The method commences with a drilling operation wherein the drill head mechanism **100** as herein described is coupled to both the rock bolt **200** and the nut element **250**. When in this first position, rotating the drill head mechanism **100** in the drilling direction, typically clockwise however could be anti-clockwise, rotates both the rock bolt main shaft **210** and the nut element **250** at the same rate in the drilling direction. As they are rotated at the same rate, the nut element **250** does not advance along the thread **235** of the rock bolt main shaft **210**.

As depicted in FIGS. **1**, **2** and **8**, the drill head mechanism **100** is typically coupled to a drive motor **400** which causes rotation of the drill head mechanism **100**. The drive motor **400** and drill head mechanism **100** may be operatively coupled to a mast **502** of a drilling assembly **500** wherein a mechanism is able to move the drive motor **400** and drill head mechanism **100** along the length of the mast **502**. When the drive motor **400** is operated which enables rotation of the drill head mechanism **100** in the drilling direction, the drill head mechanism **100** and drill motor **400** may be advanced up the mast thereby drilling the self-drilling rock bolt **200** into a rock substrate **2**.

During the drilling step, fluid (as described herein, such as water, gas, air, steam or the like) is supplied to the cutting tip **221** via the central conduit **211** for cooling and for removal of particulate material formed by the drilling process. The fluid may be supplied to the central conduit **211** via the injection nozzle **320** or by some other supply system. In the preferred embodiment, the fluid is delivered via the central channel **332** of the injection nozzle **320**. While water is a common fluid used for this purpose, any other suitable fluid may be used, such as air, steam, solvent, gases, vacuums or the like. That is, the drilling operation could be a wet or dry drilling process and include positive or negative pressure. As outlined above, it is preferred that the injection nozzle **320** does not rotate with the drive head mechanism **100** during the drilling step.

The step of anchoring the self-drilling rock bolt **200** in the strata **2** involves injecting hardening substances or the like into the void **4** surrounding the rock bolt **200** via the central conduit **211**. The injection nozzle **320** delivers hardening substances to the fluid connection port **232**, where they flow through the central conduit **211** and exit **222** at the cutting end **220** of the main shaft **210**. Suitable hardening substances may include a combination of one or more of but not limited to, adhesives, hardening compositions, polymers, catalysts, resins, resin hardeners, polymeric resins, phenolic resins, cementatious or chemical grout, vinyl toluene and the like.

With reference to FIG. **9**, once the rock bolt **200** is drilled into the strata **2** to the desired depth and anchored, the drill head mechanism **100** may be sufficiently displaced in an axial direction away from the driving portion **230** of the rock bolt **200** such that the coupling portion **130** is disengaged from the rock bolt **200** while the nut coupling portion **120** remains engaged with the outside surface **255** of the nut element **250**. While in this second position, the drill head mechanism **100** may be rotated in the same direction again (that is, the drilling direction) in a preferred embodiment, however now the nut element **250** advances along the rock bolt **200** due to the rock bolt **200** no longer being engaged to the drill head mechanism **100** and thereby remaining stationary relative to the rotating drill head mechanism **100**. The rock bolt **200** has also been at least partially glued in place at this time. The nut element **250** advances until it is pressed against the surface of the strata **2** and then tightened, placing the rock bolt main shaft **210** in tension. It should however be understood that the further rotation could be in a direction opposite to the drilling direction in certain embodiments. That is, clockwise or anti-clockwise rotation or any combination thereof can be utilised.

In FIG. **9**, in addition to the nut element **250**, there is also shown a dome washer **260** which may also advance up the shaft **210** of the self-drilling rock bolt **200** when the nut element **250** is advanced in the second position of the drill head mechanism **100**. As can be seen from FIG. **3**, the dome washer **260** may be advanced up to a bearing plate **261** which spreads the force provided by the nut element **250** being driven up the shaft **210** of the self-drilling rock bolt **200** across the surface of the strata **2**.

The rock bolt **200** may include various other washers or other components located above or about the nut element **250**, threaded onto the rock bolt main shaft **210** but ideally not engaged with the thread **235**. For example, washers are commonly used along with the plate **261** to spread the load from the nut element **250** over a greater area of the strata. Spherical washers may also be used to allow even spread of the load when the strata is not perpendicular to the rock bolt **200**. A mesh screen (not shown) may also be used that allows fluid to escape during drilling, but seals the higher viscosity resins, catalyst or other hardening substances in the void **4** surrounding the rock bolt **200**. That is, it helps stop the hardening resins from falling out of the rock bolt hole or void **4**. The mesh screen could move along the rock bolt shaft **210**.

Typically a slow setting hardening substance will be delivered first. Sufficient volume will be delivered to fill approximately two thirds of the void **4**. As the hardening substance exits **222** at the cutting end **220** it will flow down the void **4** so that it is filled from the cutting end **220** first. A fast setting hardening substance will then be supplied, filling the cutting end **220** of the void **4** and forcing the slow setting hardening substance down to the driving end **230** of the rock bolt **200**. In a preferred form, an amount of slow set hardening substance is delivered after the fast set hardening substance which provides that there is no fast set hardening substance remaining in the drill head mechanism **100** or fluid delivery system **300** on completion of the injection cycle of the assembly **1**.

In one embodiment, the hardening substances and a suitable catalyst are delivered together in a predetermined ratio and will generally mix sufficiently while flowing through the central conduit **211**. It may be desirable, however, to rotate the rock bolt **200** shortly after supplying the hardening substances, commonly referred to as "spinning" the rock bolt **200**. This would be accomplished using the drill head mechanism **100** in the first position, as during the drilling step. This will improve mixing of the hardening substances and also generate heat that may be necessary to initiate and or facilitate the hardening reaction of the hardening substances.

When the fast setting hardening substance has hardened (typically within seconds), the rock bolt **200** is now substantially anchored in the strata and may then be placed in tension. At this stage, the slow setting hardening substance has not yet hardened across a region of about the bottom two thirds of the rock bolt **200**. Typically the slow setting hardening substance takes a few minutes to set. It is this region that will be placed in tension by what is referred to as tensioning the rock bolt **200**. Once tensioned, the slow setting hardening substance will harden maintaining tension across the rock bolt **200**.

In some prior art systems that use resins for anchoring a rock bolt **200**, the resins are inserted into a pre-drilled hole in a sausage-like package. The sausage-like package can prevent resins and catalyst from mixing. For example, the sausage-like package can be inadvertently compressed at one end of the drill hole or misaligned causing the bolt to miss the catalyst and leaving unmixed resin.

The present invention removes any potential back pressurization of the hole caused by the bolt acting like a piston when pushing/spinning through the chemical cartridge therefore creating a potential piston ring at the top end of the bolt and unmixed resin. Such pressure can also contribute to the hydrofracing of the borehole strata. Hydro or hydraulic fracturing of the roof strata can occur when significant pressure is placed on the back of the hole.

One of the primary advantages of the current invention, at least in a preferred embodiment, is the possibility of automation of the system. In addition to the cost advantages, automation is desirable due to the hazardous nature of the environment in which the system is used.

To aid with automation, the nut element **250** may be temporarily fixed to the rock bolt **200** prior to use. A rubber ring **212** (best seen in FIG. **4**), wax or other similar substance may be used for this purpose, such that the nut element **250** cannot be removed simply due to vibrations or handling of the components, but fails when the drill head mechanism **100** rotates the nut element **250** to tension the rock bolt **200**. Temporarily fixing the nut element **250** in place only allows slight movements in position, which may accommodate the automation process.

An example of the steps involved in an automated or semi-automated method of installing a self-drilling rock bolt **200** with reference to the drill head mechanism **100**, self-drilling rock bolt **200**, and fluid delivery system **300** of the assembly **1** as herein before described is provided in the following but non limiting embodiment set out below.

In a first drilling step, a self-drilling rock bolt **200** as herein described is coupled to the drive head mechanism **100** wherein the bolt coupling portion **130** is engaged and the nut coupling portion **120** is engaged with the driving portion **230** of the self-drilling rock bolt **200**. A drive motor **400** is then operated which rotates the drill head mechanism **230** in the drilling direction. The self-drilling rock bolt **200** is thereby rotated by the drill head mechanism **100** and may be drilled into a strata **2** as the drill head mechanism **100** and attached self-drilling rock bolt **200** is advanced towards the strata **2**.

During the drilling step, the fluid delivery system **300** is delivering fluid in the form of flushing material to the central conduit **211** of the self-drilling rock bolt **200** to aid in the drilling process. The injection nozzle **320** of the fluid delivery system **300** is installed into the central hollow portion **111** of the drill head mechanism **100**, however the injection nozzle **320** remains stationary whilst the drill head mechanism **100** rotates. The flushing material may be delivered from two separate sources which may be delivered separately to the outer channel **332** and the central channel **332** of the injection nozzle **320** respectively. It should be appreciated that any number of sources and channels can be utilised as discussed herein and the fluid can be in many forms such as water, gas, air, steam, cleaning fluid, flushing fluid, or the like. There may be positive or negative pressure applied to the system.

Once the self-drilling rock bolt **200** is driven to a sufficient depth in strata, the drilling step ceases and the anchoring step commences. As described above, the anchoring step involves injecting a slow set hardening substance via the fluid delivery system **300** through the self-drilling rock bolt **200** such that it begins to fill the void **4** surrounding the rock bolt **200** within the strata **2**. The fluid delivery system **300** then delivers a portion of fast set hardening substance which pushes on the slow set hardening substance already delivered so that the slow set hardening substance fills the bottom portion of the void **4** towards the drilling end **220** of the rock bolt **200** and the fast set hardening substance remains in the top portion of the void **4** at the cutting tip end **221** of self-drilling rock bolt **200**. In further embodiments, a further portion of slow set substance can be delivered to the self-drilling rock bolt **200** to ensure no fast set hardening substance remains near the driving end **230** of the self-drilling rock bolt **200**. After the second slow set or in place of it a water, air or flush agent or the like is sent up to clean the fluid delivery system and connected piping after each rock bolt installation. The rock bolt **200** is then rotated (undertakes 'spinning') for a period of time (seconds) to ensure the hardening substances are mixed with any required catalyst. The rock bolt **200** is rotated by the drill head mechanism **100** in the first position. The self-drilling rock bolt **200** is then anchored once the fast set hardening substance has hardened. It should be appreciated that depending upon the circumstances more than one rock bolt length **200** can be installed in the drilled hole. That is, the assembly **1** provides the ability to automate coupled or long bolting.

Once the anchoring of the self-drilling rock bolt **200** has been finalized, the tensioning step commences. In this step, the drill head mechanism **100** is displaced away from the driving end **230** of the self-drilling rock bolt **200** such that the bolt coupling portion **130** is no longer in engagement with the driving portion **230** whilst the nut coupling portion **120** remains in engagement with the nut element **250**. The drill head mechanism **100** is then rotated in the drilling direction (in a preferred embodiment could also be opposite the drilling direction) which rotates the nut element **250**, but not the shaft **210** of the rock bolt **200** such that the nut element **250** advances up the shaft **210** of the rock bolt **200** until it is forced up against the surface of the strata and provides tension across the length of the rock bolt **200** surrounded by the slow set hardening substance. It should be appreciated that the drilling direction can be clockwise or anti-clockwise.

The self-drilling rock bolt **200** (or multiple bolts) may then be left such that the slow set hardening substance may be allowed to cure thereby providing full encapsulation of the self-drilling rock bolt(s) **200** and structural support to the strata and a second self-drilling rock bolt **200** can be engaged with the drill head mechanism **100** and installed in a different location following the same procedure as outlined above. During the drilling operation of the second self-drilling rock bolt **200** at the second location, the injection nozzle **320** may be flushed with fluid (water, steam, air, gas, cleaning fluid or the like) which also has the beneficial effect of cleaning out any remaining hardening substances from the injection nozzle **320** from the anchoring step of the previous rock bolt installation process.

Advantageously, the present invention at least in a preferred embodiment provides, a self-drilling rock bolt assembly **1** that drills it's own holes, provides full encapsulation of a rock bolt **200** by way of the injection system **300**, no gloving can occur as no sausage-like package is required, the ability to provide coupled and short bolt installation, tensioning of the bolt **200** after point anchoring, a plurality of different fluid supplies and injection means opening up an ability to utilise a range of fluids simultaneously, the ability to self-drill a bolt **200** in either direction, no need for a static mixer, fluid seals contained within the bolt reducing maintenance seals, and a computer control system that automates the process, removing workers from the operation site. The present assembly **1** can be retro fitted to existing drill rigs or be stand alone. The present invention could also be utilised in combination with rotary and rotary percussive drilling. Many other modifications will be apparent to those skilled in the art without departing from the scope of the present invention.

The invention claimed is:

1. A self-drilling rock bolt assembly including a drill head mechanism and a fluid delivery system operatively associated with each other and adapted in use to secure with pre-tension, chemically, via injection, a self-drilling rock bolt into a strata; the rock bolt including a shaft having a cutting end and a driving end; the assembly including:

a. the drill head mechanism having:
  a bolt coupling portion to releasably engage with the driving end of the rock bolt, wherein rotation of the bolt coupling portion rotates the rock bolt;
  a central hollow portion providing access to a fluid connection port of the rock bolt; and,
  a nut coupling portion to releasably engage with a nut element located on the shaft of the rock bolt, wherein rotation of the nut coupling portion rotates the nut element;
b. the fluid delivery system having:
  an injection nozzle in communication with one or more sources of fluid for delivering measured quantities of one or more fluids to a predetermined location about said assembly,
  each source of fluid including a reservoir in fluid communication with a priming pump, the priming pump being in fluid communication with a replacement pump, the displacement pump being in fluid communication with the injection nozzle, so that said fluid from said reservoir is adapted to be pumped to said predetermined location;
  a cleaning flush phase for each separate internal passage within the injection nozzle, that has each cleaning fluid sourced from a different reservoir pressure source;

whereby in use said drill head mechanism drives the rock bolt into the strata by rotating in a drilling direction the rock bolt and nut element at the same rate such that the nut element remains in the same position relative to the shaft of the rock bolt.

2. The assembly according to claim **1**, wherein the nut coupling portion drives an outside surface of the nut element.

3. The assembly according to claim **1**, wherein the bolt coupling portion includes one or more male connectors that engage with one or more corresponding female connectors of the rock bolt, the male connectors driving an inside surface of the rock bolt.

4. The assembly according to claim **3**, wherein the bolt coupling portion includes a main body with a central hollow corresponding to the central hollow of the drill head mechanism, wherein the one or more male connectors include a protrusion from a top surface of the main body extending in a direction parallel to a longitudinal axis of the central hollow and adapted to operatively couple with the female connector in the driving end of the rock bolt.

5. The assembly according to claim **4**, wherein in a first position the nut coupling portion is engaged with the nut element and the bolt coupling portion is engaged with the driving end of the rock bolt, and in a second position the nut coupling portion is engaged with the nut element and the bolt coupling portion is disengaged with the driving end of the rock bolt.

6. The assembly according to claim **5**, wherein the drill head mechanism advances the nut element along the rock bolt by rotating in the drilling direction while in the second position thereby tensioning the rock bolt.

7. The assembly according to claim **1** operatively associated with a self-drilling rock bolt, the rock bolt including:
  the shaft having a hollow portion defining a central conduit;
  the fluid connection port containing a fluid seal;
  the cutting end at one end of the shaft where a cutting tip is fixed; and,

the driving end at the other end of the shaft adapted to operatively female couple to the drill head mechanism, wherein rotation of the drill head mechanism rotates the shaft;

the shaft including an external thread at or towards the driving end that engages with the nut element such that rotation of the nut element relative to the shaft causes the nut element to move in an axial direction along the shaft.

8. The assembly according to claim **7**, wherein the central conduit provides fluid communication between a fluid connection port at the driving end and a fluid exit at the cutting end.

9. The assembly according to claim **8**, wherein the coupling end includes one or more slots arranged radially about the fluid connection port, each female slot adapted to receive therein a male connector of the bolt coupling portion of the drill head mechanism.

10. The assembly according to claim **7**, wherein the cutting tip is fixed to the rock bolt so that it creates a fluid exit for fluids to exit the central conduit.

11. The assembly according to claim **10**, further including a mesh screen surrounding the rock bolt to permit fluid to exit a void surrounding the rock bolt by flowing through the mesh screen but resists higher viscosity hardening substances flowing therethrough to exit the void.

12. The assembly according to claim **1**, wherein the fluids include one or more of:

a slow set hardening substance;

a fast set hardening substance;

a catalyst to initiate the hardening of the slow and/or fast set hardening substances;

water;

steam;

gas;

air;

cleaning fluid; and/or

flushing fluid.

13. The assembly according to claim **1**, including a control system to control the ratios and volumes of each fluid supplied to the rock bolt and movement of the drill head mechanism with respect to the strata.

14. The assembly according to claim **1**, wherein the injection nozzle includes:

a plurality of separate internal passages through which various fluids may flow;

a needle portion of elongate shape, with one end adapted to couple with the rock bolt and including openings for fluids to exit the internal passages; and,

a base portion including fluid inlets in fluid communication with the internal passages.

15. The assembly according to claim **14**, wherein the base portion of the injection nozzle includes a plurality of separate inlets, wherein more than one of the inlets may be in fluid communication with the same internal fluid passage.

16. The assembly according to claim **15**, wherein the injection nozzle in use extends through the central hollow of the drill head mechanism into the fluid connection port while the drill head mechanism is coupled with the rock bolt, and whereby in use the injection nozzle does not rotate as the drill head mechanism and/or rock bolt rotates.

17. A method of installation of the self-drilling rock bolt assembly of claim **1**, the method including the steps of:

rotating the rock bolt and the nut element together in the drilling direction using the drill head mechanism such that the rock bolt advances into the strata;

delivering the hardening substances by the fluid delivery system;

spinning the rock bolt; and,

tensioning the rock bolt by rotating the nut element in the drilling direction relative to the rock bolt, so that the rock bolt is anchored in the strata.

18. The method according to claim **17**, wherein the method further includes the steps of:

a. a slow setting hardening substance is first sent through the rock bolt, then

b. a fast setting hardening substance is sent through the rock bolt; then either or both;

c. a slow setting hardening substance is sent into the central conduit of the rock bolt;

and/or

d. a cleaning fluid is sent into the central conduit of the rock bolt; so that the rock bolt is tensioned after the fast setting hardening substance has hardened and before the slow setting hardening substance has hardened.

19. The method according to claim **17**, wherein the drill head mechanism rotates the rock bolt and nut element at the same rate in a drilling direction, causing the rock bolt to be drilled into the strata, then decouples from the rock bolt; but is still coupled to the nut via the nut coupling portion, and further rotates in the drilling direction to cause the nut element to advance along the rock bolt, thereby causing the rock bolt to be placed in tension.

20. The method according to claim **17**, wherein the fluid delivery system supplies a plurality of different fluids throughout the assembly as determined by the control system.

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